~~Designation:B918–01~~ Designation: B 918/B 918M – 09

Standard Practice for Heat Treatment of Wrought Aluminum Alloys[1]

This standard is issued under the fixed designation B 918/B 918M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice is intended for use in the heat treatment of wrought aluminum alloys for general purpose applications.

1.1.1 The heat treatment of wrought aluminum alloys used in specific aerospace applications is covered in AMS 2772.[2]

1.1.2 Heat treatment of aluminum alloy castings for general purpose applications is covered in Practice B 917/B 917M.

1.2 Times and temperatures appearing in the heat-treatment tables are typical for various forms, sizes, and manufacturing methods and may not provide the optimum heat treatment for a specific item.

1.3 Some alloys in the 6xxx series may achieve the T4 temper by quenching from within the solution temperature range during or immediately following a hot working process, such as upon emerging from an extrusion die. Such alternatives to furnace heating and immersion quenching are indicated in Table 2, by Footnote *L*, ~~for heat treatment of wrought aluminum alloys. However, this practice does not cover the requirements for a controlled press heat treatment. (Refer to Practice B807 for press heat treatment of aluminum alloys.)~~

~~1.4This practice is in inch-pound units.~~ , for heat treatment of wrought aluminum alloys. However, this practice does not cover the requirements for a controlled extrusion press or hot rolling mill solution heat treatment. (Refer to Practice B 807 for extrusion press solution heat treatment of aluminum alloys and to Practice B 947 for hot rolling mill solution heat treatment of aluminum alloys.)[3]

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 The following documents, of the issue in effect on the date of material purchase, form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[3]

B 557 Test Methods ~~of~~for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

B 881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B 917/B 917M ~~Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes[3]~~ Practice for Heat Treatment of Aluminum-Alloy Castings from All Processes

G 69 Test Method for Measurement of Corrosion Potentials of Aluminum Alloys

G 110 Practice for Evaluating Intergranular Corrosion Resistance of Heat Treatable Aluminum Alloys by Immersion in Sodium Chloride + Hydrogen Peroxide Solution

2.3 *American National Standard:*

H35.1/H35.1(M) Alloy and Temper Designation Systems for Aluminum[4]

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[1] This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

~~Current edition approved July 10, 2001. Published September 2001.~~

Current edition approved March 15, 2009. Published April 2009. Originally approved in 2001. Last previous edition approved in 2001 as B 918 – 01.

~~[2] Available from SAE-AEROSPACE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.~~

[2] Available from SAE International, 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* ~~, Vol 02.02.~~volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from American National Standards Institute (ANSI), 25 ~~West~~W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Tests Required

Product Form	Tensile Properties[A]	Heat-Treat-Induced Porosity[B] [Periodic Test]	Intergranular Corrosion[C] [Periodic Test]	Diffusion (Alclad Only)[D] [Periodic Test]	Eutectic Melting [Periodic Test]
Plate and sheet	X	X	X[E]	X	X
Wire, rod, bar, and profiles	X	X	X	. . .	X
Forgings	X	X	X	. . .	X
Tubing	X	X	. . .	X	X
Rivets, fastener components	X	X	X	. . .	X

[A] Those specified in the applicable procurement material specification for lot release.
[B] Applicable only to material solution heat-treated in air furnaces.
[C] Applicable to the most quench-sensitive alloys-tempers in the following order of preference: (*1*) 2xxx in -T3 or -T4 and (*2*) 7xxx in -T6 temper. No test is required if 2xxx-T3 or -T4 or 7xxx-T6, was not solution heat-treated during the period since the prior verification test.
[D] Not applicable for thicknesses less than 0.020 in.
[E] Applicable to periodic testing of sheet product only.

3. Terminology

3.1 *Definitions*—Refer to Terminology B 881 for definitions of product terms used in this practice.

3.2 *Definition of Pyrometry Terms Specific to This Standard:*

3.2.1 *control sensor*—~~temperature measurement sensor tied to the PID (proportional, integral, and derivative) furnace control for controlling heat input to the working (soaking) zone of the furnace.~~ —sensor connected to the furnace temperature controller, which may or may not be recording.

3.2.2 *monitoring sensor*—~~a sensor which does not control the furnace temperature is designated as a monitoring sensor, and includes additional furnace temperature sensor(s) and load monitoring sensor(s).~~ load sensor—sensor that is attached to the production material or a representation of production material, that supplies temperature data of the production material to process instrumentation.

3.2.3 *monitoring sensor*—sensor connected to the monitoring instrument.

3.2.4 *test sensor*—~~temperature measurement sensor(s) used in furnace temperature uniformity surveys.~~ —sensor used in conjunction with a test instrument to perform a system accuracy test or temperature uniformity survey.

4. Equipment

4.1 *Heating Media*—Aluminum alloys are typically heat-treated in air chamber furnaces or molten salt baths; however, lead baths, oil baths, or fluidized beds, may be used. ~~However, the~~ The use of uncontrolled heating is not permitted. Whichever heating means are employed, careful evaluation is required to ensure that the alloy being heat-treated responds properly to heat-treatment and is not damaged by overheating or by the heat-treatment environment.

4.1.1 Air chamber furnaces may be oil- or gas-fired or may be electrically heated. Furnace components that are significantly hotter than the metal should be suitably shielded for metal less than 0.250 in. [6.35 mm] thick to prevent adverse radiation effects. The atmosphere in air chamber furnaces must be controlled to prevent potential porosity resulting from solution heat treatment (see Note 1). The suitability of the atmosphere in an air-chamber furnace can be demonstrated by testing, in accordance with 7.4.2.1, that products processed in that furnace are free from heat-treat induced porosity.

NOTE 1—Heat-treat induced porosity may lower mechanical properties and commonly causes blistering of the surface of the material. The condition is most likely to occur in furnaces in which the products of combustion contact the work, particularly if the gases are high in water vapor or contain compounds of sulfur. In general, the high-strength wrought alloys of the 2xxx and 7xxx series are most susceptible. Low-strength and Alclad (two sides) products are practically immune to this type of damage. Anodic films and proprietary heat-treat coatings are also useful in protecting against porosity resulting from solution heat treatment. Surface discoloration is a normal result of solution heat treatment of aluminum alloys and should not be interpreted as evidence of damage from overheating or as heat-treat induced porosity (see 7.4.2.1).

4.1.2 Salt baths heat the work rapidly and uniformly. The temperature of the bath can be closely controlled, an important consideration in solution heat treatment of wrought aluminum alloys. High-temperature oxidation of aluminum is not a problem in salt baths.

4.2 *Furnace Temperature Uniformity and Calibration Requirements*:

4.2.1 After establishment of thermal equilibrium or a recurrent temperature pattern, the temperature in the working (soaking) zone, for all furnace control and test sensors, shall maintain temperature in the working (soaking) zone within the following allowable ranges:

4.2.1.1 50°F [28°C] range for furnaces used only for full annealing at 825°F [441°C] and higher, except 20°F [12°C] range if the annealing temperature is within 15°F [8°C] of the middle of the solution heat treating temperature range specified in Table 2.

TABLE 2 Recommended Heat Treatment for Wrought Aluminum Alloys[A]

Product	Solution Heat Treatment		Precipitation Heat Treatment[B]			
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
			2011 Alloy[A]			
Cold-finished wire, rod, and bar	945-995 [507–535]	110 [43] max	T3[F]	320 [160]	14	T8[F]
			T4	...	...	...
			T451[G]	...	...	...
Drawn tube	975 [524]	110 [43] max	T3[F]	...	...	...
			T4511[G]			
			2014 Alloy[A]			
Flat sheet, bare or Alclad	935 [502]	110 [43] max	T3[F]	...	...	...
			T42	320 [160]	18	T62
Coiled sheet, bare or Alclad	935 [502]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
Plate, bare or Alclad	935 [502]	110 [43] max	T451[G]	320 [160]	18	T651[G]
			T42	...	...	...
Cold-finished wire, rod, and bar	935 [502]	110 [43] max	T4	320 [160] or 350 [177]	18 8	T6
			T451[H]	320 [160] or 350 [177]	18 8	T651[H]
			T42	320 [160] or 350 [177]	18 8	T62
Extruded wire, rod, bar, profiles, and tube	935 [502]	110 [43] max	T4	320 [160] or 350 [177]	18 8	T6
			T4510[H]	320 [160] or 350 [177]	18 8	T6510[H]
			T4511[H]	320 [160] or 350 [177]	18 8	T6511[H]
			T42	320 [160] or 350 [177]	18 8	T62
Drawn tube	935 [502]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
Die forgings	935 [502]	140–180 [60-82]	T4	340 [171]	10	T6
Hand forgings and rolled rings	935 [502]	140–180 [60-82]	T452[I]	340 [171]	10	T652[I]
			T4	340 [171]	10	T6
			2017 Alloy[A]			
Cold-finished wire, rod, and bar	925–950 [496-510]	110 [43] max	T4	...	...	...
			T451[H]	...	...	...
			T42	...	...	...
			2018 Alloy[A]			
Die forgings	940–970 [504-521]	212 [100]	T4	340 [171]	10	T61
			2024 Alloy[A]			
Flat sheet, bare or Alclad	920 [493]	110 [43] max	T3[F]	375 [191]	12	T81[F]
			T361[J]	375 [191]	8	T861[J]
			T42	375 [191]	9	T62
			T42	375 [191]	16	T72
Coiled sheet, bare or Alclad	920 [493]	110 [43] max	T4	...	...	...
			T42	375 [191]	9	T62
Plate, bare or Alclad	920 [493]	110 [43] max	T351[G]	375 [191]	12	T851[G]
			T361[J]	375 [191]	8	T861[J]
			T42	375 [191]	9	T62
Cold-finished wire, rod, and bar	920 [493]	110 [43] max	T351[H]	375 [191]	12	T851[H]
			T36[J]	...	...	...
			T4	375 [191]	12	T6
			T42	375 [191]	16	T62
Extruded wire, rod, bar, profiles, and tube	920 [493]	110 [43] max	T3[F]	375 [191]	12	T81[F]
			T3510[H]	375 [191]	12	T8510[H]
			T3511[H]	375 [191]	12	T8511[H]
			T42	...	...	...
Drawn tube	920 [493]	110 [43] max	T3[F]	...	...	...
			T42	...	...	...
			2025 Alloy[A]			
Die forgings	960 [516]	140–160 [60-71]	T4	340 [171]	10	T6
			2117 Alloy[A]			
Cold-finished, wire or rod	925–950 [496-510]	110 [43] max	T4	...	...	...
			2124 Alloy[A]			
Plate	920 [493]	110 [43] max	T351[G]	350 [177]	12	T851[G]

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
			2218 Alloy[A]			
Die forgings	950 [510]	212 [100]	T4	340 [171]	10	T61
			2219 Alloy[A]			
Flat sheet, bare or Alclad	995 [535]	110 [43] max	T31[F]	350 [177]	18	T81[F]
			T37[K]	325 [163]	24	T87[K]
			T42	375 [191]	36	T62
Plate	995 [535]	110 [43] max	T37[K]	350 [177]	18	T87[K]
			T351[G]	350 [177]	18	T851[G]
			T42	375 [191]	36	T62
Cold-finished wire, rod, and bar	995 [535]	110 [43] max	T4	375 [191]	18	T6
			T351[H]	375 [191]	18	T851[H]
Extruded wire, rod, bar, profiles, and tube	995 [535]	110 [43] max	T31[F]	375 [191]	18	T81[F]
			T3510[H]	375 [191]	18	T8510[H]
			T3511[H]	375 [191]	18	T8511[H]
			T42	375 [191]	36	T62
Die forgings and rolled rings	995 [535]	110 [43] max	T4	375 [191]	26	T6
Hand forgings	995 [535]	110 [43] max	T4	375 [191]	26	T6
			T352[I]	350 [177]	18	T852[I]
			2618 Alloy[A]			
Die, hand, and rolled ring forgings	985 [529]	212 [100]	T4	390 [199]	20	T61
			4032 Alloy			
Die forgings	940–970 [504-521]	140–180 [60–82]	T4	340 [171]	10	T6
			6005 Alloy			
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350 [177]	8	T5
			6005A Alloy			
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350 [177]	8	T5
			6013 Alloy[A]			
Sheet, bare	1055 [568]	110 [43] max	T4	375 [191]	4	T6
				or 345 [174]	8	
Plate, bare	1020–1050 [549-566]	110 [43] max	. . .	345 [174]	8–16	T651[G]
Cold-finished wire, rod, and bar	1050 [566]	110 [43] max		375 [191]	4	T651[H]
			. . .	375 [191]	4	T8[F]
			6053 Alloy			
Cold-finished wire and rod	970 [521]	110 [43] max	T4	355 [179]	8	T61
Die forgings	970 [521]	110 [43] max	T4	340 [171]	10	T6
			6061 Alloy[A]			
Sheet, bare or Alclad	960–1075 [516-579][M]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
Plate	960–1075 [516-579]	110 [43] max	T451[G]	320 [160]	18	T651[G]
			T42	320 [160]	18	T62
Tread Sheet and Plate[N,O]	960–1075 [516-579]	110 [43] max	T4	320 [160]	18	T6
Cold-finished wire, rod, and bar	960–1075 [516-579]	110 [43] max[P]	T4	340 [171]	8	T6
				or 320 [160]	18	
			T3[F]	340 [171]	8	T89[Q,R]
				or 320 [160]	18	
			T4	340 [171]	8	T94[S]
				or 320 [160]	18	
			T451[H]	340 [171]	8	T651[H]
				or 320 [160]	18	
			T42	340 [171]	8	T62
				or 320 [160]	18	
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350 [177]	8	T51
	960–1075 [516-579][L]	110 [43] max[P]	T4	350 [177]	8	T6
			T4510[H]	350 [177]	8	T6510[H]
			T4511[H]	350 [177]	8	T6511[H]
			T42	350 [177]	8	T62
Structural profiles	960–1075 [516-579][L]	110 [43] max[P]	T4	350 [177]	8	T6
Pipe	960–1075 [516-579][L]	110 [43] max[P]	T4	350 [177]	8	T6

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
Drawn tube	960–1075 [516-579]	110 [43] max	T4	340 [171]	8	T6
				or 320 [160]	18	
			T42	340 [171]	8	T62
				or 320 [160]	18	
Die and hand forgings	960–1075 [516-579]	110 [43] max	T4	340 [171]	8	T6
				or 320 [160]	18	
Rolled rings	960–1075 [516-579]	110 [43] max	T4	350 [177]	8	T6
			T452[T]	350 [177]	8	T652[T]
		6063 Alloy				
Extruded rod, bar, tube, and profiles	. . .[L]	. . .	T1	400 [204]	1 to 2	T5
				or 360 [182]	3	
			T1	400 [204]	1 to 2	T52
				or 360 [182]	3	
	970 [521][L]	110 [43] max[P]	T4	360 [182]	6	T6
				or 350 [177]	8	
			T42	360 [182]	6	T62
				or 350 [177]	8	
Drawn tube	970 [521]	110 [43] max	T4	350 [177]	8	T6
			T3[F]	350 [177]	8	T83[R]
			T3[F]	350 [177]	8	T831[R]
			T3[F]	350 [177]	8	T832[R]
			T31[F]	. . .	. . .	. . .
			T42	350 [177]	8	T62
Pipe	970 [521][L]	110 [43] max[P]	T4	360 [182]	6	T6
				or 350 [177]	8	
		6066 Alloy				
Extruded rod, bar, profiles, and tube	960–1010 [516-543]	110 [43] max	T4	350 [177]	8	T6
			T4510[H]	350 [177]	8	T6510[H]
			T4511[H]	350 [177]	8	T6511[H]
			T42	350 [177]	8	T62
Die forgings	960–1010 [516-543]	110 [43] max	T4	350 [177]	8	T6
		6070 Alloy				
Extruded rod, bar, profiles, and tube	1015 [546]	110 [43] max	T4	320 [160]	18	T6
			T42	320 [160]	18	T62
		6101 Alloy				
Extruded rod, bare tube, pipe and structural profiles	970 [521][L]	110 [43] max[P]	T4	390 [199]	10	T6
			T4	440 [227]	5	T61
			T4	410 [210]	9	T63
			T4	535 [279]	7	T64
			T4	430 [221]	3	T65
		6105 Alloy				
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350 [177]	8	T5
		6110 Alloy				
Cold-finished wire, rod, and bar	980–1050 [527-566]	110 [43] max	T4	380 [193]	8	T9[S]
		6151 Alloy				
Die forgings	950–980 [510-527]	110 [43] max	T4	340 [171]	10	T6
Rolled rings	960 [516]	110 [43] max	T4	340 [171]	10	T6
			T452[I]	340 [171]	10	T652[I]
		6201 Alloy				
Wire	950 [510]	110 [43] max	T3	320 [160]	4	T81[R]
		6262 Alloy				
Cold-finished wire, rod, and bar	960–1050 [516-566]	110 [43] max	T4	340 [171]	8	T6
			T4	340 [171]	8	T9[S]
			T451[H]	340 [171]	8	T651[H]
Extruded rod, bar, profiles, and tube	960–1050 [516-566][L]	110 [43] max	T4	350 [177]	12	T6
			T4510[H]	350 [177]	12	T6510[H]
			T4511[H]	350 [177]	12	T6511[H]
			T42	350 [177]	12	T62
Drawn tube	960–1050 [516–566]	110 [43] max	T4	340 [171]	8	T6
			T4	340 [171]	8	T9[S]
			T42	340 [171]	8	T62

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
6351 Alloy						
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	350 [177]	8	T5
				350 [177]	8	T51
				250 [121] or 350 [177]	10 8	T54
	. . .[L]	. . .	T11	. . .	. . .	. . .
	960–1010 [516–543][L]	110 [43] max[P]	T4	350 [177]	8	T6
6463 Alloy						
Extruded rod, bar, profiles, and tube	. . .[L]	. . .	T1	400 [204] or 360 [182]	1 3	T5
	970 [521][L]	110 [43] max[P]	T4	350 [177] or 360 [182]	8 6	T6
7001 Alloy						
Extruded rod, bar, profiles, and tube	870 [466]	110 [43] max	W[U]	250 [121]	24	T6
			W510[H,U]	250 [121]	24	T6510[H]
			W511[H,U]	250 [121]	24	T6511[H]
			W[U]	250 [121]	24	T62
7005 Alloy						
Extruded rod, bar, and profiles	. . .[L]	. . .	T1	room temperature	72 plus	T53
				225 [107]	8 plus	
				300 [149]	16	
7049 Alloy						
Extruded rod, bar, and profiles	875 [468]	110 [43] max	W511[H,U]	room temperature	48 plus	T76511[H]
				250 [121]	24 plus	
				325 [163]	12 to 14	
			W511[H,U]	room temperature	48 plus	T73511[H]
				250 [121]	24 plus	
				300 [149]	12 to 21	
Die and hand forgings	875 [468]	140–160 [60–71]	W[U]	room temperature	48 plus	T73
				250 [121]	24 plus	
				330 [166]	10 to 16	
			W52[I,U]	room temperature	48 plus	T7352[I]
				250 [121]	24 plus	
				330 [166]	10 to 16	
7050 Alloy						
Plate	890 [477]	110 [43] max	W51[G,U]	250 [121]	3 to 6 plus	T7451[G]
				330 [166]	24 to 30	
			W51[G,U]	250 [121]	3 to 6 plus	T7651[G]
				330 [166]	12 to 15	
Cold-finished wire, rod	890 [477]	110 [43] max	W[U]	250 [121]	4 plus	T7
				355 [179]	8 to 12	
Extruded rod, bar, and profiles	890 [477]	110 [43] max	W510[H,U]	250 [121]	24 plus	T73510[H]
				350 [177]	12 to 15	
			W510[H,U]	250 [121]	24 plus	T74510[H]
				340 [171]	8 to 12	
			W510[H,U]	250 [121]	3 to 6 plus	T76510[H]
				315 [154]	15 to 18	
			W511[H,U]	250 [121]	24 plus	T73511[H]
				350 [177]	12 to 15	
			W511[H,U]	250 [121]	24 plus	T74511[H]
				340 [171]	8 to 12	
			W511[H,U]	250 [121]	3 to 6 plus	T76511[H]
				315 [154]	15 to 18	
Die forgings	890 [477]	140–160 [60–71]	W[U]	250 [121]	1 to 6 plus	T74
				350 [177]	4 to 12	
Hand forgings	890 [477]	140–160 [60–71]	W52[I,U]	250 [121]	1 to 6 plus	T7452
				350 [177]	4 to 8	
7075 Alloy[A]						

~~TABLE 2Recommended Heat Treatment for Wrought Aluminum Alloys[A]~~

TABLE 2 *Continued*

Product	Solution Heat Treatment			Precipitation Heat Treatment[B]		
	Metal Temperature, ±10°F [±6°C][C,D]	Quench Temperature, °F [°C][E]	Temper	Metal Temperature, ±10°F [±6°C]	Time at Temperature, h	Temper
Sheet, bare or Alclad	860–930 [460–499][V]	110 [43] max	W[U]	250 [121] or 205 [96]	24 4 plus 8	T6
			W[U]	315 [157] 225 [107] 325 [163] or 225 [107] 335 [168][W]	6 to 8 plus 24 to 30 6 to 8 plus 14 to 18	T73[X]
			W[U]	250 [121] 325 [163]	3 to 5 plus 15 to 18	T76[X]
			W[U]	250 [121] or 205 [96] 315 [157]	24 4 plus 8	T62
Plate, bare or Alclad	860–930 [460–499][V,Y]	110 [43] max	W51[G,U]	250 [121] or 205 [96]	24 4 plus 8	T651[G]
			W51[G,U]	315 [157] 225 [107] 325 [163] or 225 [107] 335 [168][W]	6 to 8 plus 24 to 30 6 to 8 plus 14 to 18	T7351[G,X]
			W51[G,U]	250 [121] 325 [163]	3 to 5 plus 15 to 18	T7651[G,X]
			W[U]	250 [121] or 205 [96] 315 [157]	24 4 plus 8	T62
Cold-finished wire, rod, and bar	860–930 [460–499][V,Y]	110 [43] max	W[U] W[U]	250 [121] 225 [107] 350 [177]	24 6 to 8 plus 8 to 10	T6 T73[X]
			W[U]	250 [121]	24	T62
			W51[G,U]	250 [121]	24	T651[H]
			W51[G,U]	225 [107] 350 [177]	6 to 8 plus 8 to 10	T7351[H,X]
Extruded rod, bar, profiles, and tube	860–930 [460–499][V,Y]	110 [43] max	W[U]	250 [121] or 210 [99] 250 [121] 300 [149]	24 5 plus 4 plus 4	T6
			W[U]	225 [107] 350 [177] or 225 [107] 335 [168]	6 to 8 plus 6 to 8 6 to 8 plus 14 to 18	T73[X]
Extruded rod, bar, profiles, and tube			W[U]	250 [121] 325 [163]	3 to 5 plus 15 to 18	T76[X]
			W[U]	250 [121] or 210 [99] 250 [121] 300 [149]	24 5 plus 4 plus 4	T62
			W510[H,U]	250 [121] or 210 [99] 250 [121] 300 [149]	24 5 plus 4 plus 4	T6510[H]
			W510[H,U]	225 [107] 350 [177] or 225 [107] 335 [168][W]	6 to 8 plus 6 to 8 6 to 8 plus 14 to 18	T73510[H,X]
			W510[H,U]	250 [121] 325 [163]	3 to 5 plus 15 to 18	T76510[H,X]
			W511[H,U]	250 [121] or 210 [99] 250 [121] 300 [149]	24 5 plus 4 plus 4	T6511[H]
			W511[H,U]	225 [107] 350 [177] or 225 [107] 335 [168][W]	6 to 8 plus 6 to 8 6 to 8 plus 14 to 18	T73511[H,X]
			W511[H,U]	250 [121] 325 [163]	3 to 5 15 to 18	T76511[H,X]
Drawn tube	870 [466]	110 [43] max	W[U] W[U]	250 [121] 225 [107] 350 [177] or 225 [107] 335 [168]	24 6 to 8 plus 6 to 8 6 to 8 plus 14 to 18	T6 T73[X]
			W[U]	250 [121]	24	T62

TABLE 2 *Continued*

Product	Solution Heat Treatment: Metal Temperature, ±10°F [±6°C][C,D]	Solution Heat Treatment: Quench Temperature, °F [°C][E]	Solution Heat Treatment: Temper	Precipitation Heat Treatment[B]: Metal Temperature, ±10°F [±6°C]	Precipitation Heat Treatment[B]: Time at Temperature, h	Precipitation Heat Treatment[B]: Temper
Die forgings	860–900	140–160 [60–71]	W[U]	250 [121]	24	T6
	[460–482]		W[U]	225 [107]	6 to 8 plus	T73[X]
				350 [177]	8 to 10	
			W52[I,U]	225 [107]	6 to 8 plus	T7352[I,X]
				350 [177]	6 to 8	
			W[U]	225 [107]	6 to 8 plus	T74
				350 [177]	6 to 8	
Hand forgings	860–900	140–160 [60–71]	W[U]	250 [121]	24	T6
	[460–482]		W[U]	225 [107]	6 to 8 plus	T73[X]
				350 [177]	8 to 10	
			W52[I,U]	225 [107]	6 to 8 plus	T7352[I,X]
				350 [177]	6 to 8	
			W[U]	225 [107]	6 to 8 plus	T74
				350 [177]	6 to 8	
			W52[I,U]	250 [121]	24	T652[I]
Rolled rings	860–900	110 [43] max	W[U]	250 [121]	24	T6
	[460–482]		W52[I,U]	250 [121]	24	T652[I]
		7116 Alloy[A]				
Extruded rod, bar, profiles, and tube	. . . [L]	. . .	W[U]	215 [102]	5 plus	T5
				330 [166]	5	
		7129 Alloy[A]				
Extruded rod, bar, profiles, and tube	. . . [L]	. . .	W[U]	215 [102]	5 plus	T5
				320 [160]	5	
	900 [482][L]	110 [43] max	W[U]	215 [102]	5 plus	T6
				320 [160]	5	
		7175 Alloy[A]				
Die and hand forgings	880 [471]	180 [82]	W[U]	225 [107]	6 to 8 plus	T74
				350 [177]	6 to 8	
			W52[I,U]	225 [107]	6 to 8 plus	T7452[I]
				350 [177]	6 to 8	
		7178 Alloy[A]				
Bare and Alclad sheet	860–900	110 [43] max	W[U]	250 [121]	24	T6
	[460–482]		W[U]	250 [121]	3 to 5 plus	T76[X]
				325 [163]	15 to 18	
			W[U]	250 [121]	24	T62
Plate, bare and Alclad	860–900	110 [43] max	W51[G,U]	250 [121]	24	T651[G]
	[460–482]		W51[G,U]	250 [121]	3 to 5 plus	T7651[G,X]
				325 [163]	15 to 18	
			W[U]	250 [121]	24	T62
Cold-finished wire and rod	870 [466]	110 [43] max	W[U]	250 [121]	24	T6
Extruded rod, bar, profiles, and tube	870 [466]	110 [43] max	W[U]	250 [121]	24	T6
			W[U]	250 [121]	3 to 5 plus	T76[X]
				320 [160]	18 to 21	
			W[U]	250 [121]	24	T62
			W510[H,U]	250 [121]	24	T6510[H]
			W510[H,U]	250 [121]	3 to 5 plus	T76510[H,X]
				320 [160]	18 to 21	
			W511[H,U]	250 [121]	24	T6511[H]
			W511[H,U]	250 [121]	3 to 5 plus	T76511[H,X]
				320 [160]	18 to 21	

[A] For specific aerospace applications, refer to SAE-AMS heat-treating and material specifications.[2]
[B] Typical or nominal time at temperature. Actual practice may vary depending on material requirements.
[C] Recommended soaking times to achieve specified metal temperature appear in Table 3.
[D] Where a temperature range exceeding 20°F [12°C] is shown, a temperature within that range shall be selected and adhered to within the ±10°F [±6°C] limits. Limits thus derived must lie totally within the range specified.
[E] Unless otherwise indicated, when material is quenched by total immersion in water, the water should be at room temperature and suitably cooled to remain below 110°F [43°C] during the quenching cycle.
[F] Cold-worked in the solution heat-treated condition, prior to precipitation heat treatment to obtain specified mechanical properties.
[G] Stress-relieved by cold stretching to a permanent set of 1½ to 3 % in the solution heat-treated condition.
[H] Stress-relieved by cold stretching to a permanent set of 1 to 3 % in the solution heat-treated condition for wire, rod, bar, profiles, and extruded tube, and ½ to 3 % for drawn tubular products.
[I] Stress relieved by cold compressing 1 to 3 % after solution heat treatment.
[J] Approximately 6 % cold-worked in the solution heat-treated condition.
[K] Approximately 7 % cold-worked in the solution heat-treated condition.
[L] With suitable control of extruding temperature and quench rate, product may be quenched upon emerging from an extrusion press instead of being furnace heat treated.
[M] For Alclad sheet the maximum temperature is 1000°F [538°C] .
[N] "Tread Plate" is a generic term and includes thicknesses below 0.250 in. [6.35 mm].

[O] Unused to avoid confusion.
[P] Upon exiting the solution heat treating furnace, spray quenching may be used on thin sections where substantiated by test results.
[Q] Unused to avoid confusion.
[R] Cold-worked in the solution heat-treated condition sufficient to produce the properties specified for this temper upon subsequent precipitation heat treatment.
[S] Cold-worked after precipitation heat treatment sufficient to produce the properties specified for this temper.
[T] Stress-relieved by 1 to 5 % cold reduction in the solution heat-treated condition.
[U] The "W" (as-quenched) condition is an unstable temper and at room temperature will change due to precipitation hardening.
[V] Under some conditions melting can occur when heating 7075 alloy above 900°F [482°C] and caution should be exercised to avoid this potential.
[W] A heat-up rate to 335°F [168°C] should be 25°F/h [14°C/h].
[X] The aging of aluminum alloys 7075 and 7178 from any temper to the T73 (applicable to alloy 7075 only) or T76 temper series requires closer than normal controls on aging practice variables such as time, temperature, heating-up rates, and so forth, for any given item. In addition to the preceding, when aging material in the T6 temper series to the T73 or T76 temper series, the specific condition of the T6 temper material (such as its property level and other effect of processing variables) is extremely important and will affect the capability of the re-aged material to conform to the requirements specified for the applicable T73 or T76 temper series.
[Y] For plate, rod, or bar over 4 in. in thickness or diameter, heat-treat 860 to 910°F [460–488°C].

Product	Solution Heat Treatment			Precipitation Heat Treatm	
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]	Temper	Metal Temperature, ±10°F	Time at Tem
			2011 Alloy[A]		
Cold-finished wire, rod, and bar	945–995	110 max	T3[F] T4 T451[G]	320	14
Drawn tube	975	110 max	T3[F] T4511[G]	...	
			2014 Alloy[A]		
Flat sheet, bare or Alclad	935	110 max	T3[F] T42	... 320	...
Coiled sheet, bare or Alclad	935	110 max	T4 T42	320 320	18
Plate, bare or Alclad	935	110 max	T451[G] T42	320 ...	16
Cold-finished wire, rod, and bar	935	110 max	T4 T451[H] T42	320 or 350 320 or 350 320 or 350	18 8 18
Extruded wire, rod, bar, profiles, and tube	935	110 max	T4 T4510[H] T4511[H] T42	320 or 350 320 or 350 320 or 350 320 or 350	18 8 18 8
Drawn tube	935	110 max	T4 T42	320 320	18
Die forgings	935	140–180	T4	340	
Hand forgings and rolled rings	935	140–180	T452[I] T4	340 340	10
			2017 Alloy[A]		
Cold-finished wire, rod, and bar	925–950	110 max	T4 T451[H] T42	... ...	...
			2018 Alloy[A]		
Die forgings	940–970	212	T4	340	
			2024 Alloy[A]		
Flat sheet, bare or Alclad	920	110 max	T3[F] T361[J] T42 T42	375 375 375 375	12 8
Coiled sheet, bare or Alclad	920	110 max	T4 T42	... 375	...
Plate, bare or Alclad	920	110 max	T351[G] T361[J] T42	375 375 375	12
Cold-finished wire, rod, and bar	920	110 max	T351[H] T36[J] T4 T42	375 ... 375 375	12 ...
Extruded wire, rod, bar, profiles, and tube	920	110 max	T3[F] T3510[H] T3511[H] T42	375 375 375 ...	12 12
Drawn tube	920	110 max	T3[F] T42	... ...	...
			2025 Alloy[A]		
Die forgings	960	140–160	T4	340	
			2117 Alloy[A]		
Cold-finished, wire or rod	925–950	110 max	T4	...	
			2124 Alloy[A]		
Plate	920	110 max	T351[G]	350	
			2218 Alloy[A]		
Die forgings	950	212	T4	340	
			2219 Alloy[A]		
Flat sheet, bare or Alclad	995	110 max	T31[F] T37[K] T42	350 325 375	18 2
Plate	995	110 max	T37[K] T351[G] T42	350 350 375	18 1
Cold-finished wire, rod, and bar	995	110 max	T4 T351[H]	375 375	18
Extruded wire, rod, bar, profiles, and tube	995	110 max	T31[F] T3510[H] T3511[H] T42	375 375 375 375	18 18
Die forgings and rolled rings	995	110 max	T4	375	2
Hand forgings	995	110 max	T4 T352[I]	375 350	26
			2618 Alloy[A]		
Die, hand, and rolled ring forgings	985	212	T4	390	2
			4032 Alloy		
Die forgings	940–970	140–180	T4	340	
			6005 Alloy		
Extruded rod, bar, profiles, and tube	...[L]	...	T1	350	

TABLE 2 *Continued*

Product	Solution Heat Treatment		Temper	Precipitation Heat Treatment	
	Metal Temperature, ±10°F[C,D]	Quench Temperature, °F[E]		Metal Temperature, ±10°F	Time at Temp
			6005A Alloy		
Extruded rod, bar, profiles, and tube	...[L]	...	T1	350	8
			6013 Alloy[A]		
Sheet, bare	1055	110 max	T4	375 or 345	4 8
Plate, bare	1020–1050	110 max	...	345	8–16
Cold-finished wire, rod, and bar	1050	110 max	... ...	375 375	4 4
			6053 Alloy		
Cold-finished wire and rod	970	110 max	T4	355	8
Die forgings	970	110 max	T4	340	10
			6061 Alloy[A]		
Sheet, bare or Alclad	960–1075[M]	110 max	T4 T42	320 320	18 18
Plate	960–1075	110 max	T451[G] T42	320 320	18 18
Tread Sheet and Plate[N,O]	960–1075	110 max	T4	320	18
Cold-finished wire, rod, and bar	960–1075	110 max[P]	T4 T3[F] T4 T451[H] T42	340 or 320 340 or 320 340 or 320 340 or 320 340 or 320	8 18 8 18 8 1 18
Extruded rod, bar, profiles, and tube	...[L] 960–1075[L]	... 110 max[P]	T1 T4 T4510[H] T4511[H] T42	350 350 350 350 350	8 8 8 8
Structural profiles	960–1075[L]	110 max[P]	T4	350	8
Pipe	960–1075[L]	110 max[P]	T4	350	8
Drawn tube	960–1075	110 max	T4 T42	340 or 320 340 or 320	8 18 8
Die and hand forgings	960–1075	110 max	T4	340 or 320	8 18
Rolled rings	960–1075	110 max	T4 T452[T]	350 350	8 8
			6063 Alloy		
Extruded rod, bar, tube, and profiles	...[L] 970[L]	... 110 max[P]	T1 T1 T4 T42	400 or 360 400 or 360 360 or 350 360 or 350	1 to 2 3 1 to 8
Drawn tube	970	110 max	T4 T3[F] T3[F] T3[F] T31[F] T42	350 350 350 350 ... 350	8 8 8 8
Pipe	970[L]	110 max[P]	T4	360 or 350	6 8
			6066 Alloy		
Extruded rod, bar, profiles, and tube	960–1010	110 max	T4 T4510[H] T4511[H] T42	350 350 350 350	8 8 8
Die forgings	960–1010	110 max	T4	350	8
			6070 Alloy		
Extruded rod, bar, profiles, and tube	1015	110 max	T4 T42	320 320	18 18
			6101 Alloy		
Extruded rod, bare tube, pipe and structural profiles	970[L]	110 max[P]	T4 T4 T4 T4 T4	390 440 410 535 430	10 5 9
			6105 Alloy		
Extruded rod, bar, profiles, and tube	...[L]	...	T1	350	8
			6110 Alloy		
Cold-finished wire, rod, and bar	980–1050	110 max	T4	380	8
			6151 Alloy		
Die forgings	950–980	110 max	T4	340	10
Rolled rings	960	110 max	T4 T452[I]	340 340	10 10
			6201 Alloy		
Wire	950	110 max	T3	320	4
			6262 Alloy		
Cold-finished wire, rod, and bar	960–1050	110 max	T4 T4 T451[H]	340 340 340	8 8 8
Extruded rod, bar, profiles, and tube	960–1050[L]	110 max	T4 T4510[H] T4511[H] T42	350 350 350 350	12 12 12
Drawn tube	960–1050	110 max	T4 T4 T42	340 340 340	8 8 8
			6351 Alloy		
Extruded rod, bar, profiles, and tube	...[L] ...[L] 960–1010[L]	... ... 110 max[P]	T1 T11 T4	350 350 250 or 350 ... 350	8 8 10 8
			6463 Alloy		
Extruded rod, bar, profiles, and tube	...[L] 970[L]	... 110 max[P]	T1 T4	400 or 360 350 or 360	1 3 8
			7001 Alloy		
Extruded rod, bar, profiles, and tube	870	110 max	W[U] W510[H,U] W511[H,U] W[U]	250 250 250 250	24 24 24